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Evaluation and identification of promising multivoltine germplasm accessions using sub ordinate function method

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Abstract
Central Sericultural Germplasm Resources Centre, Hosur is conserving and in possession of 81 multivoltine silkworm genetic resources presently which comprises 71 indigenous and 10 exotic origins. India being a country of tropical climate majority of the silk produced is multivoltine when compared with the temperate bivoltine silk produced in the sericulturally advanced country like China. Hence it becomes a necessity to make continuous efforts to breed for hardy and productive bivoltine silkworm breeds which will withstand the tropical climates prevailing in the Indian sub continent. Though there has been substantial improvement in the bivoltine silk produced in the country over the years, still majority of the silk produced are of multivoltine type, but the concept of Improved Cross Breeds (ICBs) have come into force where in the superior multivoltine breeds are developed and crossed with bivoltine breeds yielding silk which will match the international quality standards of 2A - 4A grade silk. To meet this requirement there is need for diverse parental breeds which can contribute as breeding resource materials in the development of ICBs so that a variety of breeds could be evolved which can contribute and improve the silk production. The breeders look for thoroughly evaluated and proven and stable breeds which can contribute to their resources base. CSGRC, Hosur with such a large and diverse collection of silkworm germplasm could be an important nodal centre in contributing to the needs of the breeders by providing parental materials for breeding towards achieving higher productivity and quality silk. Therefore an attempt has been made to evaluate and short list 73 potential multivoltine silkworm germplasm accessions using one of the proven evaluation technique of sub ordinate function method which is a handy tool in short listing germplasm and for selection of multiple traits. Potential accessions performing better over different seasons and better performing ones in all environments have been identified and recommended for the silkworm breeders to use them as resources materials.

Keywords: multivoltine, silkworm, germplasm, accessions, sub ordinate function

Introduction
Sericulture in India is farm based, labour oriented commercial activity suited to rural based farmers providing high employment and good returns and an important means of livelihood for vast majority of the rural population of the country. India being the country of tropical climatic conditions is mainly dependent on the crossbreed and multivoltine type of silk production. In fact sericulture industry in India is multivoltine oriented and about 75 % of the mulberry silk production is of multivoltine origin and the rest is bivoltine. Though there has been wide spread requirement for the superior and high quality bivoltine silk at the same time it is not possible to get bivoltine silk production from our farmers throughout the year. But it is quite possible to develop crossbreeds through selection of better multivoltine parent from our genetic wealth and produce high quality cross bred silk. Further the climatic conditions in the tropical countries like ours exhibit wide fluctuations in the weather parameters and this situation coupled with the inferior quality of mulberry leaves and poor management practices by the farmers requires hardy and flexible races.

The statistics of production of silk as per 2016-17 shows 30348 M.T. out of which Mulberry silk is 21273 M.T. (70.09%, 5266 M.T. BV and 16007 M.T. CB), Tasar 3268 M.T., Eri 5637 and Muga 170 M.T. The major chunk of the mulberry silk (75.24 %) produced is still from cross breed only but with Improved Cross Breeds (ICBs) (Anonymous, 2017). In this context, evolving superior multivoltine parental breeds suiting to the tropical climatic conditions and better combiner in the crossbreed dfls production is very much essential.

Silkworm breeding is conducted mainly to bring together all appropriate gene combinations to improve the genetic manifestation and cocoon yield and productivity per unit area. The genetic variability in different genetic resources serves as ways and means to bring in a more desirable gene combination through conventional breeding. The desirable level of success depends on the selection of initial breeding resource material, their effective utilization in different gene combinations to the genetic expressions of character under consideration (Mano, *et al*., 1992) [12]. Parents as resource material are a prerequisite contributing to the success of breeding potential breeds/ hybrids. Thorough and proper evaluation of the genetic resources and utilization of the native breeds of potential nature will help the breeder to select most effective genotypes before choosing the materials for breeding. The silkworm breeders have various statistical methods like two way classification (Kempthorne, 1952 and 1957) [7, 8], Subordinate function Index (Gower, 1971a, b) [5, 6] Joint scoring method (Arunachalam and Bandyopadhyay,

1984) [2] and multiple trait evaluation Index method (Mano *et al*., 1993) [13] in selecting the better parental races (Nirmal Kumar, 1995) [15]; Nirmal Kumar and Sreerama Reddy (1998) [16]. CSGRC, Hosur with a large collections of diverse silkworm germplasm could serve as an important role in contributing to the needs of the breeders not only as parental materials for higher productivity and quality silk but also in breeding for hardy silkworm breeds which can withstand the harsh and not so conducive tropical climates prevailing in the country. In this study an attempt has been made to evaluate and short list 73 potential multivoltine silkworm germplasm accessions using one of the proven evaluation methodology of sub ordinate function method which is a handy tool in short listing large number of germplasm and for selection of multiple traits.

Materials and Methods

The 73 multivoltine silkworm accessions conserved at CSGRC, Hosur of various geographical origin and nature were taken for the study. The experiments were conducted in three seasons *viz.*, summer, rainy and winter in two years in completely randomized lock design with two replications of 300 larvae each and observations recorded on the 12 quantitative traits of rearing parameters and 3 reeling traits of commercial value such as fecundity (no.), hatching percentage (%), weight of 10 larvae (g), total larval duration (h), fifth age larval duration (h), ERR (by no.), ERR (by wt.) (kg.), pupation rate (%), single cocoon weight (g), single shell weight (g), cocoon shell percentage and cocoon yield/100dfls and filament length (m), non broken filament length (m) and denier. The standard rearing techniques as recommended by Krishnaswami (1978) [9] were followed.

Subordinate function method is used in biological sciences to shortlist the unwanted genotypes. It is another class of scaling method aimed at making the variation of the transformed characters as equal as possible. The intention is to allow each character to contribute towards the overall resemblance inversely in proportion to its variability among the entire set of characters. Thus a character with a small range of variation contributes as much as another character with a large variation range. The most logical to subtract the mean does not appear to have been proposed. The simplest form of equalizing both size and variability is by ranging as used by Gower (1971a, b) [5, 6] in his coefficient. In ranging, the smallest value for the characters is subtracted from each value and the results are divided by the range.

The values of subordinate function method are calculated using the following formula

$$Xu = (Xi - Xmin) / (X max - X min)$$

Where

Xu: Subordinate function

Xi: measurement of character

X min: Minimum value of the character among all the tested genotypes.

X max: Maximum value of the character among all the tested genotypes.

The smallest state among the values then has the value 0 and the largest state has the value of 1.

Results

Ranking of breeds as per sub ordinate function values

The performance of all the 73 multivoltine accessions on the 15 economic traits, rearing (12) traits and reeling (3) traits for the three seasons were recorded. Based on the sub ordinate function values and cumulative values better performing accessions for particular seasons. were found out. Also the pooled data analysis resulted in the promising accessions based on the total score and presented.

Summer Season

The trait wise sub ordinate scores for the summer season was worked out for all the 73 multivoltine accessions and the cumulative scores for the summer season ranged from a maximum of 9.22 to a minimum of 3.75 (Table-1). Accessions BMI-0066 recorded the highest total score of 9.22 followed by accessions BMI-0074 (8.64), BMI-0065(8.13), BMI-003 (7.64) and BMI-0043(7.25). The accession BME-0012 scored the least score of 3.75.

Table 1: Ranking of accessions based on sub ordinate function coefficient scores for the economic traits and total scores (summer season)

Acc. No.	Fec	Hat %	Wt_10	Tld	Vld	ERR no.	ERR wt.	Pupa %	Cocoon	Shell	SR %	CY/100dfls	FIL-LEN	NBF	DENIER	Total score
BMI-0066	0.61	0.74	1.00	0.15	0.26	0.58	0.70	0.78	1.00	0.77	0.52	0.69	0.91	0.92	0.62	9.22
BMI-0074	0.90	0.85	0.60	0.29	0.49	0.53	0.61	0.67	0.87	1.00	1.00	0.60	0.46	0.55	0.59	8.64
BMI-0065	0.74	0.77	0.75	0.21	0.36	0.85	0.51	0.90	0.69	0.75	0.85	0.51	0.38	0.43	0.82	8.13
BMI-0003	0.65	0.77	0.59	0.01	0.05	0.65	1.00	0.80	0.35	0.33	0.62	1.00	0.39	0.48	0.56	7.64
BMI-0043	0.80	0.55	0.54	0.04	0.16	0.76	0.37	0.80	0.40	0.41	0.67	0.36	0.77	0.81	0.60	7.25
BMI-0041	0.74	0.73	0.60	0.21	0.43	0.67	0.77	0.55	0.42	0.31	0.41	0.76	0.57	0.50	0.68	7.03
BMI-0067	0.78	0.68	0.56	1.00	1.00	0.74	0.55	0.95	0.53	0.43	0.51	0.55	0.19	0.38	0.57	6.85
BMI-0014	0.29	0.60	0.55	0.24	0.33	0.66	0.43	0.73	0.39	0.44	0.72	0.43	0.83	0.69	0.11	6.77
BMI-0027	0.33	0.69	0.53	0.21	0.43	0.42	0.61	0.65	0.43	0.47	0.72	0.61	0.63	0.61	0.77	6.69
BMI-0001	0.61	1.00	0.48	0.93	0.92	0.60	0.60	0.88	0.62	0.45	0.43	0.60	0.15	0.24	0.67	6.66
BMI-0039	0.73	0.88	0.54	0.01	0.12	0.65	0.55	0.71	0.29	0.26	0.49	0.55	0.38	0.47	0.60	6.49
BMI-0059	0.85	0.54	0.64	0.09	0.18	0.95	0.52	0.91	0.53	0.39	0.46	0.51	0.08	0.09	0.92	6.48
BMI-0061	0.41	0.70	0.58	0.14	0.25	0.70	0.37	0.81	0.55	0.49	0.60	0.37	0.39	0.50	0.74	6.47
BMI-0037	0.66	0.79	0.65	0.00	0.10	0.71	0.59	0.70	0.37	0.25	0.38	0.59	0.30	0.36	0.86	6.35
BMI-0034	0.75	0.63	0.50	0.13	0.30	0.88	0.16	0.88	0.32	0.24	0.43	0.17	0.81	0.56	0.81	6.31
BMI-0025	0.64	0.67	0.64	0.14	0.25	0.27	0.58	0.60	0.46	0.34	0.42	0.58	0.61	0.46	0.45	6.27
BMI-0045	0.32	0.28	0.57	0.05	0.18	0.77	0.58	0.93	0.33	0.31	0.55	0.58	0.56	0.43	0.66	6.21

Acc. No.	Fec	Hat %	Wt_10	Tld	Vld	ERR no.	ERR wt.	Pupa %	Cocoon	Shell	SR %	CY/100dfls	FIL-LEN	NBF	DENIER	Total score
BMI-0058	0.66	0.60	0.61	0.09	0.18	0.92	0.63	0.85	0.45	0.25	0.28	0.63	0.15	0.11	0.73	6.14
BME-0048	0.34	0.42	0.74	0.16	0.35	0.78	0.34	0.89	0.46	0.49	0.72	0.33	0.41	0.20	0.53	6.13
BMI-0062	0.39	0.42	0.51	0.22	0.38	0.84	0.44	0.84	0.56	0.45	0.50	0.44	0.36	0.37	0.59	6.12
BMI-0008	0.52	0.45	0.50	0.15	0.26	0.41	0.41	0.71	0.40	0.35	0.54	0.41	0.67	0.71	0.26	6.09
BMI-0026	0.50	0.46	0.59	0.21	0.36	0.28	0.66	0.59	0.60	0.38	0.35	0.65	0.63	0.39	0.74	6.09
BMI-0009	0.45	0.52	0.35	0.15	0.26	0.43	0.32	0.77	0.38	0.23	0.31	0.32	1.00	1.00	0.26	6.08
BMI-0023	0.64	0.30	0.34	0.11	0.21	0.69	0.39	0.69	0.42	0.49	0.76	0.39	0.61	0.34	0.76	6.07
BMI-0040	0.72	0.58	0.56	0.14	0.32	0.85	0.34	0.76	0.47	0.27	0.32	0.34	0.44	0.37	0.71	6.02
BMI-0071	0.77	0.85	0.32	0.25	0.43	0.67	0.24	0.75	0.34	0.33	0.55	0.23	0.36	0.52	0.67	5.93
BME-0050	0.67	0.65	0.48	0.09	0.24	1.00	0.28	0.76	0.31	0.19	0.37	0.29	0.46	0.46	0.63	5.91
BMI-0073	0.42	0.38	0.41	0.21	0.36	0.86	0.27	0.89	0.55	0.69	0.91	0.27	0.06	0.19	0.50	5.89
BMI-0046	0.71	0.54	0.55	0.06	0.19	0.86	0.47	1.00	0.34	0.24	0.43	0.46	0.25	0.02	0.58	5.87
BMI-0010	0.51	0.53	0.18	0.03	0.09	0.81	0.44	0.92	0.28	0.14	0.27	0.44	0.66	0.60	0.00	5.77
BMI-0038	0.46	0.55	0.71	0.01	0.11	0.84	0.37	0.78	0.40	0.19	0.25	0.36	0.42	0.39	0.53	5.72
BMI-0006	0.66	0.34	0.40	0.04	0.10	0.70	0.47	0.85	0.20	0.03	0.16	0.47	0.60	0.67	0.53	5.56
BMI-0019	0.74	0.60	0.39	0.04	0.10	0.65	0.35	0.86	0.19	0.15	0.43	0.35	0.42	0.41	0.44	5.54
BMI-0056	0.54	0.57	0.45	0.18	0.32	0.86	0.36	0.87	0.31	0.19	0.32	0.35	0.40	0.30	0.57	5.53
BMI-0004	0.33	0.75	0.27	0.00	0.03	0.60	0.53	0.81	0.31	0.19	0.34	0.53	0.41	0.46	0.61	5.53
BME-0015	0.73	0.59	0.41	0.04	0.10	0.59	0.31	0.82	0.37	0.13	0.21	0.31	0.57	0.46	0.06	5.49
BME-0052	0.77	0.82	0.31	0.28	0.55	0.54	0.42	0.68	0.39	0.33	0.57	0.42	0.16	0.06	0.50	5.46
BMI-0021	0.46	0.57	0.03	0.01	0.00	0.65	0.24	0.88	0.10	0.14	0.54	0.23	0.70	0.85	0.53	5.39
BME-0005	0.71	0.85	0.41	0.01	0.04	0.70	0.38	0.87	0.35	0.19	0.28	0.37	0.08	0.13	0.30	5.33
BMI-0069	0.76	0.67	0.25	0.22	0.38	0.46	0.32	0.71	0.37	0.33	0.53	0.32	0.28	0.34	0.67	5.33
BMI-0016	0.00	0.45	0.39	0.11	0.21	0.42	0.25	0.81	0.43	0.33	0.45	0.25	0.78	0.73	0.08	5.28
BMI-0068	0.73	0.59	0.17	0.22	0.38	0.78	0.31	0.94	0.32	0.21	0.33	0.30	0.23	0.29	0.56	5.22
BMI-0024	1.00	0.84	0.40	0.15	0.26	0.43	0.11	0.77	0.17	0.13	0.40	0.11	0.44	0.38	0.66	5.19
BMI-0072	0.45	0.72	0.41	0.21	0.36	0.70	0.30	0.86	0.48	0.28	0.32	0.30	0.13	0.20	0.88	5.15
BMI-0057	0.34	0.19	0.50	0.18	0.32	0.76	0.27	0.89	0.37	0.37	0.59	0.27	0.40	0.16	0.86	5.12
BMI-0044	0.57	0.59	0.57	0.06	0.19	0.60	0.36	0.72	0.41	0.24	0.33	0.35	0.35	0.00	0.71	5.10
BMI-0002	0.45	0.48	0.19	0.15	0.26	0.28	0.62	0.64	0.26	0.31	0.65	0.63	0.24	0.34	0.55	5.09
BMI-0029	0.36	0.52	0.35	0.06	0.19	0.63	0.21	0.83	0.15	0.09	0.35	0.21	0.71	0.67	0.34	5.07
BMI-0053	0.29	0.42	0.27	0.10	0.25	0.98	0.23	0.98	0.19	0.15	0.42	0.23	0.35	0.49	0.62	5.01
BME-0049	0.44	0.53	0.42	0.10	0.25	0.70	0.26	0.80	0.29	0.14	0.27	0.26	0.38	0.40	0.43	4.91
BME-0047	0.23	0.44	0.31	0.05	0.18	0.65	0.58	0.86	0.15	0.15	0.45	0.58	0.28	0.20	0.89	4.90
BMI-0007	0.71	0.63	0.45	0.11	0.21	0.00	0.43	0.54	0.41	0.32	0.45	0.43	0.19	0.32	0.45	4.87
BMI-0018	0.64	0.63	0.36	0.04	0.10	0.70	0.36	0.88	0.12	0.11	0.42	0.36	0.10	0.16	0.81	4.86
BMI-0028	0.22	0.57	0.35	0.13	0.31	0.66	0.47	0.86	0.17	0.06	0.26	0.48	0.36	0.39	0.70	4.86
BME-0030	0.31	0.00	0.47	0.18	0.38	0.46	0.37	0.62	0.29	0.32	0.60	0.37	0.61	0.42	0.88	4.84
BMI-0033	0.36	0.43	0.32	0.11	0.27	0.80	0.21	0.85	0.23	0.13	0.32	0.21	0.60	0.38	0.85	4.83
BMI-0011	0.33	0.49	0.22	0.11	0.21	0.61	0.22	0.85	0.23	0.17	0.44	0.22	0.51	0.47	0.42	4.76
BMI-0042	0.45	0.68	0.43	0.11	0.27	0.55	0.24	0.83	0.23	0.18	0.45	0.24	0.24	0.23	0.60	4.76
BMI-0036	0.60	0.34	0.55	0.06	0.20	0.77	0.41	0.77	0.32	0.15	0.23	0.41	0.09	0.11	0.83	4.75
BMI-0060	0.34	0.39	0.58	0.09	0.18	0.65	0.31	0.71	0.46	0.26	0.30	0.31	0.19	0.19	0.92	4.69
BMI-0070	0.30	0.60	0.35	0.24	0.42	0.61	0.23	0.81	0.40	0.39	0.60	0.23	0.00	0.15	1.00	4.67
BMI-0020	0.34	0.62	0.00	0.15	0.26	0.64	0.42	0.78	0.30	0.27	0.49	0.42	0.13	0.23	0.49	4.65
BMI-0035	0.45	0.36	0.57	0.00	0.10	0.79	0.26	0.81	0.28	0.13	0.26	0.27	0.23	0.07	0.48	4.49
BMI-0032	0.31	0.21	0.30	0.11	0.27	0.84	0.15	0.75	0.14	0.07	0.26	0.15	0.72	0.39	0.77	4.29
BMI-0054	0.48	0.65	0.37	0.17	0.23	0.21	0.23	0.47	0.20	0.24	0.59	0.23	0.42	0.13	0.75	4.23
BMI-0017	0.33	0.48	0.28	0.04	0.10	0.37	0.42	0.72	0.18	0.06	0.24	0.42	0.35	0.37	0.40	4.22
BMI-0063	0.37	0.76	0.34	0.17	0.30	0.88	0.29	0.71	0.22	0.01	0.08	0.30	0.05	0.21	0.55	4.22
BME-0013	0.47	0.33	0.21	0.13	0.24	0.71	0.24	0.87	0.33	0.10	0.13	0.24	0.27	0.22	0.10	4.11
BMI-0031	0.35	0.48	0.12	0.18	0.38	0.78	0.00	0.90	0.00	0.00	0.39	0.00	0.50	0.52	0.71	4.05
BMI-0055	0.79	0.63	0.24	0.21	0.30	0.06	0.24	0.00	0.21	0.13	0.36	0.24	0.72	0.40	0.37	4.01
BMI-0022	0.19	0.20	0.36	0.13	0.23	0.69	0.11	0.77	0.33	0.27	0.47	0.11	0.34	0.09	0.56	3.93
BMI-0064	0.45	0.55	0.32	0.04	0.10	0.73	0.36	0.67	0.27	0.00	0.00	0.36	0.02	0.18	0.63	3.92
BME-0012	0.69	0.78	0.11	0.26	0.45	0.60	0.02	0.63	0.18	0.12	0.34	0.02	0.06	0.20	0.50	3.75

Acc. No.-Accession Number, Fec.-Fecundity, Hat %-Hatching Percentage, Wt_10-Weight of 10 larvae, Tld-Total larval duration, Vld- Fifth age larval duration, ERR no.- Effective Rate of Rearing by number, ERR wt.- Effective Rate of Rearing by weight, Pupa %-Pupation percentage, Cocoon-Cocoon weight, Shell-Shell weight, SR%-Shell Ratio, CY/100dfls-cocoon Yield/100dfls, FIL-LEN-Filament Length, NBF-Non Broken Filament Length.

Rainy Season

The range of total scores using the sub ordinate values during the rainy season revealed a highest range of 10.27 to the lowest value of 2.84 (Table-2). The total score of 10.27 was recorded in accession BMI-0074. Accessions BMI-0066 (9.22) and BMI-0065 (8.77) and BMI-027 (8.19) were the other top performing accessions. BMI-0001 was the least performing accession with a total score of 2.84.

Table 2: Ranking of accessions based on sub ordinate function coefficent scores for the economic traits and total scores (rainy season)

Acc. No.	Fec	Hat %	Wt_10	Tld	Vld	ERR no.	ERR wt.	Pupa %	Cocoon	Shell	SR %	CY/100dfls	FIL-LEN	NBF	DENIER	Total score
BMI-0074	1.00	0.90	1.00	0.04	0.08	0.79	0.91	0.87	0.86	1.00	1.00	0.91	0.46	0.55	0.59	10.27
BMI-0066	0.38	0.69	0.82	0.18	0.31	0.66	1.00	0.71	0.83	0.75	0.55	1.00	0.91	0.92	0.62	9.22
BMI-0065	0.68	0.74	0.84	0.18	0.31	0.87	0.80	0.95	0.73	0.77	0.77	0.80	0.38	0.43	0.82	8.77
BMI-0027	0.35	0.64	0.46	0.20	0.35	0.80	0.92	0.97	0.68	0.65	0.56	0.92	0.63	0.61	0.77	8.19
BMI-0043	0.78	0.60	0.63	0.09	0.15	0.78	0.65	0.67	0.53	0.51	0.52	0.65	0.77	0.81	0.60	7.91
BMI-0014	0.26	0.77	0.53	0.23	0.40	0.99	0.67	0.96	0.51	0.50	0.50	0.67	0.83	0.69	0.11	7.86
BMI-0009	0.44	0.42	0.42	0.11	0.19	0.73	0.82	0.80	0.53	0.43	0.33	0.83	1.00	1.00	0.26	7.74
BMI-0023	0.62	0.71	0.47	0.24	0.42	0.82	0.72	0.91	0.43	0.57	0.75	0.72	0.61	0.34	0.76	7.67
BMI-0025	0.52	0.56	0.92	0.10	0.17	0.77	0.72	0.72	0.71	0.54	0.32	0.73	0.61	0.46	0.45	7.58
BMI-0039	0.86	0.88	0.63	0.07	0.12	0.85	0.81	0.85	0.34	0.31	0.30	0.81	0.38	0.47	0.60	7.49
BME-0012	0.84	0.58	0.71	0.20	0.35	0.87	0.83	0.79	0.56	0.58	0.60	0.83	0.06	0.20	0.50	7.45
BMI-0034	0.86	0.79	0.52	0.07	0.12	0.97	0.60	0.89	0.34	0.26	0.20	0.60	0.81	0.56	0.81	7.41
BMI-0026	0.32	0.59	0.76	0.10	0.17	0.72	0.80	0.90	0.63	0.51	0.34	0.80	0.63	0.39	0.74	7.39
BME-0048	0.30	0.64	0.89	0.07	0.12	0.92	0.76	0.83	0.36	0.46	0.62	0.75	0.41	0.20	0.53	7.14
BMI-0041	0.77	0.57	0.55	0.07	0.12	0.75	0.74	0.82	0.37	0.34	0.40	0.74	0.57	0.50	0.68	7.11
BMI-0007	0.71	0.46	0.68	0.11	0.19	0.65	0.85	0.54	1.00	0.66	0.19	0.85	0.19	0.32	0.45	7.10
BMI-0059	0.97	1.00	0.56	0.16	0.27	0.76	0.86	0.71	0.42	0.35	0.30	0.86	0.08	0.09	0.92	6.96
BMI-0073	0.37	0.49	0.81	0.20	0.35	0.62	0.63	0.73	0.64	0.81	0.97	0.63	0.06	0.19	0.50	6.95
BMI-0008	0.53	0.56	0.47	0.11	0.19	0.62	0.70	0.80	0.56	0.37	0.18	0.71	0.67	0.71	0.26	6.88
BMI-0071	0.85	0.61	0.07	0.20	0.35	0.83	0.62	0.85	0.36	0.49	0.67	0.62	0.36	0.52	0.67	6.85
BMI-0069	0.84	0.62	0.14	0.20	0.35	1.00	0.43	1.00	0.46	0.58	0.73	0.43	0.28	0.34	0.67	6.85
BMI-0024	0.94	0.87	0.55	0.10	0.17	0.20	0.67	0.55	0.61	0.50	0.41	0.67	0.44	0.38	0.66	6.79
BMI-0003	0.72	0.75	0.62	0.07	0.12	0.85	0.46	0.94	0.53	0.34	0.16	0.46	0.39	0.48	0.56	6.71
BMI-0061	0.40	0.63	0.80	0.20	0.35	0.73	0.50	0.73	0.41	0.48	0.59	0.50	0.39	0.50	0.74	6.66
BMI-0045	0.36	0.60	0.57	0.09	0.15	0.86	0.70	0.83	0.42	0.32	0.28	0.70	0.56	0.43	0.66	6.64
BMI-0040	0.79	0.46	0.59	0.09	0.15	0.88	0.68	0.93	0.31	0.24	0.21	0.68	0.44	0.37	0.71	6.58
BME-0030	0.25	0.65	0.42	0.08	0.13	0.86	0.45	0.92	0.39	0.46	0.61	0.46	0.61	0.42	0.88	6.50
BMI-0006	0.54	0.46	0.42	0.00	0.00	0.91	0.59	0.84	0.47	0.29	0.12	0.59	0.60	0.67	0.53	6.50
BME-0052	0.76	0.66	0.28	0.13	0.23	0.98	0.66	0.85	0.45	0.43	0.45	0.66	0.16	0.06	0.50	6.39
BMI-0054	0.38	0.45	0.93	0.20	0.35	0.84	0.58	0.71	0.55	0.44	0.32	0.58	0.42	0.13	0.75	6.32
BMI-0019	0.82	0.58	0.33	0.09	0.15	0.82	0.41	0.93	0.37	0.34	0.39	0.42	0.42	0.41	0.44	6.24
BMI-0037	0.80	0.95	0.54	0.07	0.12	0.81	0.39	0.86	0.31	0.26	0.26	0.39	0.30	0.36	0.86	6.24
BMI-0062	0.45	0.52	0.51	0.16	0.27	0.79	0.55	0.79	0.40	0.43	0.53	0.55	0.36	0.37	0.59	6.23
BMI-0038	0.35	0.74	0.55	0.07	0.12	0.84	0.66	0.81	0.35	0.23	0.15	0.66	0.42	0.39	0.53	6.15
BMI-0042	0.47	0.67	0.54	0.09	0.15	0.70	0.71	0.82	0.33	0.33	0.39	0.71	0.24	0.23	0.60	6.14
BMI-0016	0.00	0.62	0.33	0.09	0.15	0.93	0.38	0.95	0.38	0.32	0.28	0.38	0.78	0.73	0.08	6.09
BMI-0033	0.46	0.72	0.47	0.07	0.12	0.71	0.57	0.62	0.35	0.30	0.31	0.57	0.60	0.38	0.85	6.06
BMI-0021	0.45	0.73	0.17	0.07	0.12	1.00	0.20	0.98	0.12	0.21	0.43	0.20	0.70	0.85	0.53	6.04
BMI-0067	0.79	0.72	0.13	1.00	1.00	0.83	0.39	0.97	0.39	0.40	0.41	0.39	0.19	0.38	0.57	5.99
BMI-0056	0.53	0.77	0.56	0.16	0.27	0.76	0.61	0.67	0.35	0.25	0.17	0.61	0.40	0.30	0.57	5.99
BMI-0058	0.60	0.79	0.37	0.16	0.27	0.77	0.71	0.81	0.46	0.30	0.12	0.70	0.15	0.11	0.73	5.90
BME-0050	0.57	0.82	0.34	0.02	0.04	0.87	0.39	0.83	0.34	0.24	0.16	0.39	0.46	0.46	0.63	5.86
BME-0049	0.37	0.70	0.50	0.02	0.04	0.87	0.57	0.75	0.38	0.24	0.11	0.57	0.38	0.40	0.43	5.83
BMI-0055	0.70	0.68	0.65	0.20	0.35	0.28	0.55	0.14	0.42	0.38	0.36	0.56	0.72	0.40	0.37	5.83
BME-0015	0.79	0.79	0.31	0.07	0.12	0.77	0.32	0.93	0.18	0.16	0.24	0.32	0.57	0.46	0.06	5.83
BMI-0068	0.64	0.76	0.11	0.20	0.35	0.74	0.53	0.79	0.32	0.38	0.49	0.53	0.23	0.29	0.56	5.81
BMI-0036	0.70	0.71	0.47	0.07	0.12	0.91	0.61	0.84	0.31	0.23	0.19	0.61	0.09	0.11	0.83	5.79
BMI-0032	0.26	0.51	0.41	0.07	0.12	0.78	0.42	0.69	0.34	0.36	0.44	0.43	0.72	0.39	0.77	5.75
BMI-0044	0.57	0.83	0.45	0.09	0.15	0.74	0.61	0.60	0.41	0.31	0.24	0.61	0.35	0.00	0.71	5.73
BMI-0060	0.33	0.66	0.43	0.17	0.29	0.91	0.63	0.81	0.39	0.31	0.22	0.63	0.19	0.19	0.92	5.69
BMI-0046	0.60	0.77	0.56	0.09	0.15	0.83	0.48	0.90	0.36	0.22	0.09	0.48	0.25	0.02	0.58	5.57
BMI-0022	0.12	0.45	0.43	0.10	0.17	0.87	0.51	0.88	0.42	0.40	0.42	0.51	0.34	0.09	0.56	5.44
BMI-0053	0.21	0.43	0.32	0.00	0.00	0.91	0.46	0.84	0.20	0.27	0.46	0.46	0.35	0.49	0.62	5.42
BMI-0017	0.42	0.71	0.35	0.09	0.15	0.86	0.31	0.99	0.23	0.22	0.27	0.31	0.35	0.37	0.40	5.40
BMI-0070	0.29	0.45	0.32	0.20	0.35	0.91	0.35	0.91	0.51	0.55	0.58	0.35	0.00	0.15	1.00	5.37

Acc. No.	Fec	Hat %	Wt_10	Tld	Vld	ERR no.	ERR wt.	Pupa %	Cocoon	Shell	SR %	CY/100dfls	FIL-LEN	NBF	DENIER	Total score
BMI-0010	0.50	0.65	0.10	0.11	0.19	0.54	0.51	0.72	0.30	0.16	0.02	0.51	0.66	0.60	0.00	5.29
BMI-0020	0.28	0.84	0.23	0.20	0.35	0.77	0.47	0.65	0.33	0.38	0.45	0.47	0.13	0.23	0.49	5.24
BMI-0011	0.29	0.51	0.33	0.11	0.19	0.68	0.51	0.77	0.25	0.20	0.22	0.51	0.51	0.47	0.42	5.23
BMI-0004	0.40	0.00	0.51	0.00	0.00	0.73	0.42	0.85	0.37	0.31	0.30	0.42	0.41	0.46	0.61	5.17
BME-0047	0.20	0.29	0.21	0.07	0.12	0.90	0.71	0.86	0.18	0.23	0.36	0.72	0.28	0.20	0.89	5.14
BMI-0028	0.22	0.66	0.28	0.04	0.08	0.79	0.28	0.88	0.33	0.32	0.33	0.28	0.36	0.39	0.70	5.12
BMI-0072	0.52	0.28	0.37	0.09	0.15	0.83	0.53	0.88	0.37	0.28	0.19	0.53	0.13	0.20	0.88	5.11
BMI-0002	0.41	0.64	0.31	0.07	0.12	0.83	0.39	0.86	0.33	0.20	0.08	0.39	0.24	0.34	0.55	5.02
BME-0005	0.73	0.61	0.39	0.00	0.00	0.98	0.33	0.92	0.33	0.16	0.00	0.34	0.08	0.13	0.30	5.00
BME-0013	0.51	0.38	0.44	0.04	0.08	0.78	0.38	0.92	0.39	0.23	0.07	0.37	0.27	0.22	0.10	4.95
BMI-0029	0.35	0.62	0.13	0.07	0.12	0.83	0.12	0.86	0.10	0.13	0.27	0.12	0.71	0.67	0.34	4.91
BMI-0057	0.17	0.22	0.46	0.16	0.27	0.72	0.58	0.63	0.32	0.31	0.31	0.58	0.40	0.16	0.86	4.86
BMI-0031	0.40	0.59	0.17	0.04	0.08	0.84	0.19	0.92	0.10	0.13	0.26	0.20	0.50	0.52	0.71	4.83
BMI-0035	0.44	0.64	0.41	0.07	0.12	0.82	0.39	0.81	0.27	0.15	0.06	0.39	0.23	0.07	0.48	4.67
BMI-0018	0.61	0.85	0.00	0.09	0.15	0.80	0.23	0.90	0.12	0.12	0.22	0.23	0.10	0.16	0.81	4.35
BMI-0064	0.52	0.57	0.28	0.16	0.27	0.81	0.31	0.81	0.28	0.15	0.04	0.31	0.02	0.18	0.63	4.28
BMI-0063	0.33	0.67	0.23	0.16	0.27	0.97	0.07	0.93	0.00	0.00	0.05	0.07	0.05	0.21	0.55	3.60
BMI-0001	0.42	0.85	0.26	1.00	1.00	0.00	0.00	0.00	0.30	0.29	0.32	0.00	0.15	0.24	0.67	2.84

Acc. No.-Accession Number, Fec.-Fecundity, Hat %-Hatching Percentage, Wt_10-Weight of 10 larvae, Tld-Total larval duration, Vld- Fifth age larval duration, ERR no.- Effective Rate of Rearing by number, ERR wt.- Effective Rate of Rearing by weight, Pupa %-Pupation percentage, Cocoon-Cocoon weight, Shell-Shell weight, SR%-Shell Ratio, CY/100dfls-cocoon Yield/100dfls, FIL-LEN-Filament Length, NBF-Non Broken Filament Length.

Winter Season

During the winter season the total sub ordinate scores among the 73 multivoltine accessions ranged between 9.31 to 2.91 (Table-3). The highest total score of 9.31 was scored by accession no. BMI-0074 followed by accession BMI-0066 (7.53), BME-012 (7.52), BMI-0065 (7.38) and BMI-0043 (7.33). Accession BMI-0047 scored the least total score of 3.48 among the 73 MV accessions studied.

Table 3: Ranking of accessions based on sub ordinate function coefficient scores for the economic traits and total scores (winter season)

Acc. No.	Fec	Hat %	Wt_10	Tld	Vld	ERR no.	ERR wt.	Pupa %	Cocoon	Shell	SR %	CY/100dfls	FIL-LEN	NBF	DENIER	Total score
BMI-0074	0.99	0.91	1.00	0.41	0.43	0.19	1.00	0.49	0.70	1.00	1.00	1.00	0.46	0.55	0.59	9.31
BMI-0066	0.34	0.55	0.99	0.25	0.23	0.06	0.86	0.09	0.66	0.69	0.61	0.85	0.91	0.92	0.62	7.53
BME-0012	0.70	0.69	0.80	0.29	1.00	0.66	0.80	0.61	1.00	0.76	0.45	0.79	0.06	0.20	0.50	7.52
BMI-0065	0.77	0.64	0.79	0.25	0.23	0.51	0.71	0.54	0.58	0.65	0.66	0.71	0.38	0.43	0.82	7.38
BMI-0043	0.76	0.43	0.62	0.25	0.23	0.40	0.60	0.64	0.48	0.58	0.67	0.60	0.77	0.81	0.60	7.35
BMI-0067	0.66	1.00	0.58	1.00	0.76	0.81	0.31	0.87	0.49	0.62	0.73	0.30	0.19	0.38	0.57	6.92
BMI-0009	0.33	0.51	0.41	0.30	0.57	0.71	0.52	0.65	0.33	0.33	0.47	0.52	1.00	1.00	0.26	6.80
BMI-0025	0.52	0.51	0.78	0.11	0.14	0.43	0.55	0.70	0.70	0.53	0.39	0.54	0.61	0.46	0.45	6.71
BMI-0026	0.32	0.51	0.67	0.11	0.14	0.30	0.56	0.47	0.76	0.71	0.56	0.55	0.63	0.39	0.74	6.42
BMI-0054	0.42	0.36	0.78	0.25	0.23	1.00	0.46	0.88	0.57	0.49	0.45	0.45	0.42	0.13	0.75	6.41
BMI-0071	0.74	0.84	0.21	0.18	0.14	0.47	0.51	0.57	0.45	0.54	0.65	0.50	0.36	0.52	0.67	6.36
BME-0048	0.29	0.64	0.87	0.18	0.14	0.75	0.51	0.42	0.65	0.57	0.48	0.51	0.41	0.20	0.53	6.30
BMI-0008	0.41	0.50	0.58	0.18	0.50	0.14	0.67	0.35	0.61	0.52	0.47	0.67	0.67	0.71	0.26	6.28
BMI-0034	0.63	0.89	0.49	0.07	0.00	0.76	0.32	0.61	0.19	0.20	0.43	0.32	0.81	0.56	0.81	6.21
BMI-0073	0.38	0.59	0.60	0.18	0.14	0.57	0.54	0.36	0.55	0.80	0.93	0.53	0.06	0.19	0.50	6.10
BMI-0014	0.24	0.52	0.29	0.29	0.36	0.21	0.46	0.40	0.59	0.69	0.70	0.45	0.83	0.69	0.11	6.06
BMI-0024	1.00	0.82	0.71	0.18	0.23	0.13	0.57	0.21	0.52	0.37	0.35	0.56	0.44	0.38	0.66	6.06
BMI-0007	0.61	0.50	0.89	0.32	0.68	0.27	0.54	0.58	0.54	0.54	0.56	0.54	0.19	0.32	0.45	6.05
BMI-0002	0.38	0.55	0.37	0.18	0.50	0.89	0.39	1.00	0.35	0.46	0.66	0.38	0.24	0.34	0.55	6.01
BMI-0003	0.68	0.74	0.43	0.18	0.50	0.42	0.43	0.68	0.51	0.39	0.37	0.43	0.39	0.48	0.56	5.96
BMI-0006	0.35	0.62	0.40	0.18	0.50	0.54	0.51	0.56	0.50	0.34	0.30	0.51	0.60	0.67	0.53	5.91
BMI-0055	0.83	0.57	0.56	0.36	0.36	0.29	0.48	0.11	0.60	0.45	0.38	0.47	0.72	0.40	0.37	5.87
BMI-0023	0.62	0.85	0.33	0.18	0.23	0.05	0.50	0.31	0.61	0.60	0.54	0.49	0.61	0.34	0.76	5.85
BMI-0027	0.23	0.41	0.43	0.25	0.23	0.00	0.70	0.00	0.70	0.70	0.63	0.69	0.63	0.61	0.77	5.72
BME-0052	0.72	0.48	0.45	0.25	0.23	0.44	0.57	0.58	0.58	0.54	0.54	0.56	0.16	0.06	0.50	5.69
BMI-0072	0.57	0.55	0.35	0.18	0.14	0.77	0.52	0.72	0.55	0.41	0.36	0.51	0.13	0.20	0.88	5.66
BMI-0056	0.50	0.52	0.66	0.18	0.14	0.30	0.63	0.56	0.47	0.31	0.31	0.62	0.40	0.30	0.57	5.59
BMI-0039	0.80	0.50	0.43	0.07	0.00	0.62	0.35	0.58	0.40	0.27	0.33	0.35	0.38	0.47	0.60	5.47
BME-0050	0.73	0.35	0.21	0.18	0.14	0.74	0.34	0.83	0.28	0.28	0.42	0.34	0.46	0.46	0.63	5.45

Acc. No.	Fec	Hat %	Wt_10	Tld	Vld	ERR no.	ERR wt.	Pupa %	Cocoon	Shell	SR %	CY/100dfls	FIL-LEN	NBF	DENIER	Total score
BMI-0040	0.69	0.50	0.43	0.25	0.23	0.44	0.57	0.52	0.41	0.27	0.27	0.56	0.44	0.37	0.71	5.45
BMI-0041	0.51	0.46	0.46	0.25	0.23	0.32	0.49	0.48	0.51	0.34	0.29	0.48	0.57	0.50	0.68	5.42
BMI-0068	0.68	0.63	0.00	0.25	0.23	0.62	0.41	0.51	0.28	0.51	0.83	0.40	0.23	0.29	0.56	5.40
BMI-0001	0.69	0.65	0.44	0.79	0.71	0.56	0.13	0.70	0.45	0.54	0.63	0.12	0.15	0.24	0.67	5.29
BMI-0010	0.45	0.50	0.19	0.54	0.77	0.38	0.44	0.70	0.46	0.24	0.19	0.43	0.66	0.60	0.00	5.26
BMI-0057	0.25	0.24	0.46	0.25	0.23	0.55	0.49	0.71	0.52	0.46	0.46	0.48	0.40	0.16	0.86	5.20
BMI-0062	0.36	0.46	0.52	0.07	0.00	0.31	0.59	0.36	0.43	0.38	0.41	0.58	0.36	0.37	0.59	5.13
BMI-0045	0.19	0.48	0.56	0.07	0.00	0.32	0.55	0.45	0.40	0.29	0.34	0.55	0.56	0.43	0.66	5.11
BMI-0059	0.82	0.69	0.60	0.14	0.09	0.55	0.31	0.54	0.42	0.33	0.36	0.31	0.08	0.09	0.92	5.11
BMI-0021	0.45	0.33	0.06	0.04	0.05	0.39	0.35	0.75	0.23	0.21	0.37	0.34	0.70	0.85	0.53	5.04
BMI-0058	0.74	0.74	0.52	0.07	0.00	0.40	0.40	0.69	0.25	0.23	0.37	0.40	0.15	0.11	0.73	5.02
BME-0005	0.58	0.91	0.35	0.07	0.36	0.62	0.32	0.77	0.36	0.24	0.31	0.31	0.08	0.13	0.30	4.98
BMI-0031	0.38	0.67	0.26	0.18	0.14	0.61	0.10	0.78	0.12	0.25	0.55	0.10	0.50	0.52	0.71	4.86
BMI-0011	0.24	0.53	0.26	0.43	0.64	0.51	0.38	0.62	0.37	0.23	0.28	0.38	0.51	0.47	0.42	4.78
BMI-0038	0.37	0.54	0.52	0.07	0.00	0.67	0.19	0.62	0.42	0.24	0.19	0.19	0.42	0.39	0.53	4.77
BME-0013	0.28	0.46	0.70	0.07	0.36	0.64	0.40	0.67	0.29	0.18	0.26	0.39	0.27	0.22	0.10	4.76
BMI-0069	0.62	0.69	0.06	0.18	0.14	0.21	0.23	0.41	0.27	0.54	0.88	0.23	0.28	0.34	0.67	4.75
BMI-0046	0.63	0.59	0.38	0.07	0.00	0.48	0.40	0.66	0.29	0.23	0.34	0.40	0.25	0.02	0.58	4.67
BME-0015	0.67	0.68	0.11	0.07	0.00	0.48	0.12	0.69	0.43	0.18	0.14	0.11	0.57	0.46	0.06	4.65
BMI-0033	0.28	0.47	0.35	0.18	0.14	0.41	0.43	0.33	0.18	0.23	0.45	0.43	0.60	0.38	0.85	4.54
BMI-0061	0.27	0.32	0.45	0.14	0.09	0.13	0.48	0.24	0.43	0.39	0.47	0.47	0.39	0.50	0.74	4.54
BME-0030	0.07	0.44	0.35	0.25	0.23	0.61	0.17	0.85	0.29	0.23	0.33	0.17	0.61	0.42	0.88	4.54
BME-0049	0.45	0.51	0.44	0.07	0.00	0.60	0.32	0.26	0.23	0.22	0.39	0.32	0.38	0.40	0.43	4.52
BMI-0032	0.05	0.23	0.25	0.18	0.14	0.39	0.42	0.73	0.25	0.24	0.38	0.42	0.72	0.39	0.77	4.48
BMI-0019	0.74	0.62	0.17	0.00	0.00	0.53	0.17	0.74	0.25	0.11	0.16	0.17	0.42	0.41	0.44	4.48
BMI-0022	0.04	0.49	0.20	0.07	0.09	0.66	0.30	0.41	0.37	0.54	0.74	0.29	0.34	0.09	0.56	4.46
BMI-0037	0.72	0.62	0.50	0.07	0.00	0.39	0.30	0.24	0.18	0.16	0.33	0.30	0.30	0.36	0.86	4.41
BMI-0016	0.00	0.27	0.19	0.07	0.00	0.60	0.24	0.62	0.25	0.17	0.28	0.24	0.78	0.73	0.08	4.36
BMI-0004	0.26	0.51	0.46	0.07	0.36	0.20	0.45	0.42	0.35	0.17	0.18	0.44	0.41	0.46	0.61	4.31
BMI-0070	0.14	0.14	0.07	0.18	0.14	0.57	0.50	0.43	0.36	0.58	0.81	0.49	0.00	0.15	1.00	4.22
BMI-0036	0.66	0.72	0.36	0.07	0.00	0.75	0.21	0.59	0.25	0.11	0.18	0.20	0.09	0.11	0.83	4.22
BMI-0044	0.68	0.71	0.41	0.07	0.00	0.11	0.40	0.37	0.35	0.19	0.24	0.40	0.35	0.00	0.71	4.22
BMI-0042	0.42	0.50	0.47	0.18	0.14	0.17	0.36	0.42	0.42	0.31	0.32	0.35	0.24	0.23	0.60	4.21
BMI-0053	0.18	0.15	0.36	0.18	0.14	0.50	0.20	0.64	0.28	0.30	0.46	0.20	0.35	0.49	0.62	4.13
BMI-0020	0.38	0.67	0.15	0.11	0.14	0.24	0.30	0.29	0.21	0.31	0.59	0.30	0.13	0.23	0.49	3.83
BMI-0028	0.06	0.34	0.22	0.14	0.09	0.50	0.25	0.61	0.34	0.16	0.20	0.25	0.36	0.39	0.70	3.67
BMI-0017	0.25	0.79	0.16	0.07	0.00	0.56	0.13	0.54	0.13	0.01	0.13	0.12	0.35	0.37	0.40	3.54
BMI-0060	0.29	0.43	0.29	0.07	0.00	0.18	0.43	0.28	0.17	0.20	0.44	0.42	0.19	0.19	0.92	3.52
BMI-0035	0.49	0.48	0.42	0.07	0.00	0.61	0.01	0.50	0.25	0.15	0.25	0.01	0.23	0.07	0.48	3.47
BMI-0063	0.37	0.32	0.22	0.07	0.00	0.66	0.33	0.68	0.17	0.00	0.05	0.33	0.05	0.21	0.55	3.40
BMI-0029	0.30	0.41	0.04	0.07	0.00	0.33	0.00	0.34	0.00	0.07	0.36	0.00	0.71	0.67	0.34	3.22
BMI-0064	0.44	0.00	0.14	0.18	0.14	0.69	0.35	0.70	0.24	0.01	0.00	0.35	0.02	0.18	0.63	3.11
BMI-0018	0.46	0.45	0.02	0.04	0.00	0.51	0.04	0.55	0.15	0.13	0.32	0.04	0.10	0.16	0.81	2.94
BME-0047	0.13	0.16	0.17	0.07	0.00	0.53	0.27	0.44	0.09	0.08	0.30	0.26	0.28	0.20	0.89	2.91

Acc. No.-Accession Number, Fec.-Fecundity, Hat %-Hatching Percentage, Wt_10-Weight of 10 larvae, Tld-Total larval duration, Vld- Fifth age larval duration, ERR no.- Effective Rate of Rearing by number, ERR wt.- Effective Rate of Rearing by weight, Pupa %-Pupation percentage, Cocoon-Cocoon weight, Shell-Shell weight, SR%-Shell Ratio, CY/100dfls-cocoon Yield/100dfls, FIL-LEN-Filament Length, NBF-Non Broken Filament Length.

Pooled Season

The sub ordinate scores for the pooled season were recorded for all the 15 traits and presented in table-4. The scores were added and the total scores were worked out. The total scores ranged from 9.61 to 3.48. Ranking of the 73 multivoltine accessions based on the total scores revealed accession BMI-0074 with a highest score 9.61 followed by BMI-0066 (8.36), BMI-0065 (8.23), BMI-0043(6.89) and BMI-0003(6.74). The least score was recorded in the accession BMI-0064(3.48).

Based on the performance of the accessions over the seasons and on the pooled data analysis the accessions BMI-0074, BMI-0066, BMI-0065, BMI-0043, BMI-0027, BMI-0025 and BMI-0048 are some of the potential accessions which have performed well during all the seasons and hence they can be used as potential parental breeds for use in future breeding programmes.

Table 4: Ranking of accessions based on sub ordinate function coefficient scores for the economic traits and total scores(pooled seasons)

Acc. No.	Fec	Hat %	Wt_10	Tld	Vld	ERR no.	ERR wt.	Pupa %	Cocoon	Shell	SR %	CY/100dfls	FIL-LEN	NBF	DENIER	Total score
BMI-0074	0.98	1.00	0.93	0.22	0.33	0.55	0.98	0.74	0.98	1.00	1.00	0.99	0.46	0.55	0.59	9.61
BMI-0066	0.46	0.67	1.00	0.17	0.25	0.42	1.00	0.60	1.00	0.74	0.56	1.00	0.91	0.92	0.62	8.36
BMI-0065	0.74	0.75	0.84	0.19	0.28	0.83	0.77	0.89	0.79	0.73	0.76	0.77	0.38	0.43	0.82	8.23
BMI-0043	0.80	0.48	0.60	0.11	0.16	0.69	0.58	0.73	0.53	0.50	0.62	0.58	0.77	0.81	0.60	6.89
BMI-0003	0.70	0.80	0.54	0.07	0.23	0.71	0.73	0.87	0.52	0.35	0.39	0.73	0.39	0.48	0.56	6.74
BMI-0027	0.31	0.56	0.46	0.20	0.31	0.45	0.85	0.66	0.71	0.61	0.64	0.85	0.63	0.61	0.77	6.72
BMI-0025	0.57	0.55	0.82	0.09	0.15	0.51	0.69	0.68	0.73	0.47	0.37	0.69	0.61	0.46	0.45	6.71
BME-0048	0.32	0.52	0.89	0.11	0.16	0.92	0.57	0.79	0.56	0.51	0.60	0.57	0.41	0.20	0.53	6.66
BMI-0014	0.27	0.64	0.44	0.24	0.37	0.76	0.56	0.79	0.56	0.54	0.65	0.56	0.83	0.69	0.11	6.58
BMI-0026	0.40	0.46	0.70	0.11	0.18	0.43	0.76	0.71	0.78	0.53	0.41	0.76	0.63	0.39	0.74	6.57
BMI-0067	0.76	0.85	0.39	1.00	1.00	0.85	0.43	1.00	0.52	0.47	0.55	0.43	0.19	0.38	0.57	6.45
BMI-0023	0.64	0.59	0.35	0.16	0.27	0.58	0.58	0.72	0.55	0.55	0.68	0.58	0.61	0.34	0.76	6.43
BMI-0059	0.90	0.81	0.60	0.11	0.14	0.80	0.61	0.77	0.51	0.35	0.37	0.61	0.08	0.09	0.92	6.41
BMI-0039	0.81	0.83	0.53	0.03	0.02	0.77	0.62	0.77	0.36	0.27	0.37	0.63	0.38	0.47	0.60	6.34
BME-0012	0.76	0.69	0.55	0.23	0.69	0.78	0.59	0.71	0.68	0.48	0.45	0.58	0.06	0.20	0.50	6.33
BMI-0041	0.70	0.56	0.53	0.15	0.23	0.61	0.76	0.66	0.47	0.33	0.36	0.76	0.57	0.50	0.68	6.31
BMI-0034	0.76	0.82	0.49	0.06	0.08	1.00	0.34	0.86	0.28	0.24	0.36	0.34	0.81	0.56	0.81	6.30
BMI-0073	0.40	0.39	0.63	0.18	0.25	0.66	0.50	0.73	0.67	0.76	0.93	0.50	0.06	0.19	0.50	6.24
BME-0052	0.77	0.67	0.30	0.20	0.31	0.77	0.60	0.75	0.53	0.43	0.52	0.60	0.16	0.06	0.50	6.10
BMI-0071	0.80	0.81	0.13	0.19	0.27	0.72	0.47	0.78	0.41	0.45	0.62	0.47	0.36	0.52	0.67	6.01
BMI-0009	0.42	0.40	0.36	0.17	0.36	0.63	0.60	0.78	0.46	0.33	0.37	0.60	1.00	1.00	0.26	5.93
BMI-0008	0.50	0.44	0.51	0.12	0.33	0.35	0.66	0.69	0.60	0.41	0.40	0.66	0.67	0.71	0.26	5.89
BMI-0007	0.69	0.47	0.70	0.16	0.40	0.26	0.67	0.54	0.78	0.51	0.41	0.67	0.19	0.32	0.45	5.88
BMI-0040	0.75	0.44	0.52	0.14	0.21	0.82	0.57	0.81	0.43	0.25	0.26	0.57	0.44	0.37	0.71	5.85
BMI-0058	0.68	0.74	0.48	0.09	0.09	0.75	0.64	0.83	0.42	0.25	0.26	0.64	0.15	0.11	0.73	5.84
BMI-0045	0.30	0.36	0.57	0.05	0.05	0.73	0.68	0.81	0.41	0.31	0.39	0.68	0.56	0.43	0.66	5.81
BMI-0024	1.00	0.94	0.55	0.12	0.19	0.03	0.46	0.55	0.48	0.34	0.38	0.45	0.44	0.38	0.66	5.63
BMI-0062	0.41	0.38	0.50	0.13	0.16	0.70	0.57	0.74	0.51	0.42	0.47	0.57	0.36	0.37	0.59	5.62
BMI-0056	0.54	0.62	0.55	0.15	0.21	0.68	0.58	0.74	0.40	0.25	0.26	0.57	0.40	0.30	0.57	5.59
BMI-0054	0.44	0.41	0.73	0.19	0.25	0.72	0.43	0.67	0.49	0.39	0.46	0.42	0.42	0.13	0.75	5.58
BMI-0037	0.74	0.87	0.56	0.03	0.01	0.69	0.45	0.69	0.28	0.22	0.32	0.45	0.30	0.36	0.86	5.57
BMI-0061	0.37	0.52	0.62	0.14	0.19	0.54	0.47	0.66	0.51	0.45	0.55	0.47	0.39	0.50	0.74	5.56
BMI-0046	0.66	0.63	0.49	0.05	0.05	0.80	0.47	0.93	0.34	0.23	0.29	0.47	0.25	0.02	0.58	5.56
BMI-0006	0.54	0.37	0.37	0.05	0.21	0.81	0.57	0.82	0.42	0.22	0.19	0.57	0.60	0.67	0.53	5.48
BMI-0069	0.76	0.66	0.07	0.18	0.26	0.69	0.31	0.80	0.39	0.49	0.71	0.31	0.28	0.34	0.67	5.45
BME-0050	0.67	0.62	0.30	0.07	0.09	0.96	0.32	0.84	0.31	0.24	0.32	0.32	0.46	0.46	0.63	5.35
BMI-0038	0.41	0.60	0.60	0.03	0.01	0.85	0.41	0.78	0.42	0.22	0.19	0.40	0.42	0.39	0.53	5.30
BMI-0068	0.70	0.67	0.00	0.20	0.30	0.74	0.42	0.82	0.31	0.36	0.55	0.42	0.23	0.29	0.56	5.22
BMI-0072	0.52	0.44	0.34	0.13	0.18	0.82	0.46	0.88	0.52	0.32	0.29	0.47	0.13	0.20	0.88	5.19
BME-0005	0.69	0.84	0.35	0.00	0.12	0.89	0.33	0.91	0.36	0.20	0.20	0.33	0.08	0.13	0.30	5.18
BMI-0044	0.61	0.74	0.45	0.05	0.05	0.51	0.48	0.60	0.42	0.25	0.26	0.47	0.35	0.00	0.71	5.15
BMI-0002	0.43	0.51	0.24	0.11	0.30	0.70	0.50	0.85	0.32	0.31	0.48	0.50	0.24	0.34	0.55	5.09
BMI-0019	0.78	0.57	0.25	0.02	0.03	0.72	0.28	0.91	0.26	0.21	0.32	0.28	0.42	0.41	0.44	5.00
BMI-0036	0.66	0.56	0.44	0.04	0.04	0.91	0.41	0.79	0.29	0.16	0.19	0.41	0.09	0.11	0.83	4.90
BMI-0042	0.45	0.61	0.47	0.10	0.15	0.47	0.44	0.76	0.33	0.27	0.38	0.44	0.24	0.23	0.60	4.87
BME-0015	0.75	0.71	0.22	0.04	0.01	0.65	0.20	0.88	0.33	0.16	0.18	0.20	0.57	0.46	0.06	4.84
BME-0049	0.43	0.56	0.43	0.04	0.03	0.81	0.38	0.68	0.30	0.20	0.26	0.38	0.38	0.40	0.43	4.79
BME-0030	0.22	0.22	0.39	0.15	0.22	0.71	0.31	0.83	0.33	0.34	0.50	0.31	0.61	0.42	0.88	4.77
BMI-0010	0.50	0.52	0.08	0.21	0.40	0.51	0.49	0.82	0.36	0.18	0.16	0.49	0.66	0.60	0.00	4.77
BMI-0057	0.26	0.00	0.46	0.18	0.25	0.69	0.46	0.77	0.44	0.37	0.46	0.46	0.40	0.16	0.86	4.77
BMI-0033	0.37	0.49	0.35	0.10	0.13	0.66	0.40	0.65	0.24	0.22	0.36	0.40	0.60	0.38	0.85	4.74
BMI-0070	0.25	0.30	0.19	0.19	0.27	0.78	0.35	0.80	0.47	0.51	0.67	0.35	0.00	0.15	1.00	4.66
BMI-0021	0.46	0.51	0.00	0.02	0.00	0.82	0.23	0.94	0.10	0.19	0.44	0.22	0.70	0.85	0.53	4.62
BMI-0055	0.79	0.62	0.47	0.24	0.34	0.00	0.43	0.00	0.45	0.32	0.36	0.43	0.72	0.40	0.37	4.59
BMI-0060	0.33	0.42	0.41	0.09	0.10	0.68	0.47	0.67	0.35	0.25	0.32	0.47	0.19	0.19	0.92	4.57
BMI-0004	0.34	0.28	0.39	0.00	0.12	0.53	0.50	0.77	0.35	0.22	0.26	0.50	0.41	0.46	0.61	4.54
BMI-0016	0.00	0.37	0.25	0.07	0.06	0.74	0.25	0.87	0.37	0.27	0.33	0.25	0.78	0.73	0.08	4.49
BMI-0022	0.12	0.24	0.29	0.08	0.12	0.82	0.27	0.76	0.39	0.40	0.55	0.27	0.34	0.09	0.56	4.45
BMI-0020	0.34	0.75	0.05	0.13	0.22	0.59	0.40	0.62	0.28	0.31	0.51	0.40	0.13	0.23	0.49	4.39
BMI-0001	0.58	0.94	0.36	0.90	0.95	0.07	0.21	0.44	0.50	0.42	0.47	0.21	0.15	0.24	0.67	4.35
BMI-0011	0.30	0.44	0.21	0.20	0.38	0.59	0.36	0.79	0.28	0.20	0.31	0.36	0.51	0.47	0.42	4.34

Acc. No.	Fec	Hat %	Wt_10	Tld	Vld	ERR no.	ERR wt.	Pupa %	Cocoon	Shell	SR %	CY/100dfls	FIL-LEN	NBF	DENIER	Total score
BME-0013	0.43	0.25	0.43	0.06	0.22	0.74	0.32	0.89	0.35	0.17	0.15	0.31	0.27	0.22	0.10	4.32
BMI-0032	0.22	0.17	0.28	0.10	0.13	0.72	0.31	0.74	0.23	0.23	0.35	0.31	0.72	0.39	0.77	4.26
BMI-0053	0.23	0.20	0.27	0.07	0.08	0.91	0.26	0.89	0.20	0.24	0.44	0.26	0.35	0.49	0.62	4.26
BMI-0028	0.18	0.48	0.23	0.08	0.11	0.69	0.33	0.85	0.28	0.18	0.25	0.33	0.36	0.39	0.70	4.14
BME-0047	0.19	0.13	0.17	0.04	0.04	0.78	0.56	0.80	0.09	0.15	0.37	0.56	0.28	0.20	0.89	4.08
BMI-0035	0.47	0.42	0.45	0.03	0.01	0.80	0.16	0.77	0.25	0.14	0.19	0.16	0.23	0.07	0.48	4.04
BMI-0017	0.34	0.65	0.21	0.05	0.03	0.66	0.26	0.83	0.14	0.10	0.20	0.25	0.35	0.37	0.40	3.99
BMI-0031	0.39	0.53	0.11	0.11	0.16	0.81	0.00	0.93	0.00	0.12	0.41	0.00	0.50	0.52	0.71	3.81
BMI-0018	0.59	0.66	0.04	0.03	0.03	0.72	0.16	0.85	0.08	0.12	0.32	0.16	0.10	0.16	0.81	3.79
BMI-0029	0.34	0.47	0.09	0.04	0.04	0.66	0.02	0.76	0.01	0.10	0.32	0.02	0.71	0.67	0.34	3.51
BMI-0063	0.37	0.57	0.21	0.11	0.13	0.97	0.19	0.83	0.07	0.00	0.05	0.19	0.05	0.21	0.55	3.50
BMI-0064	0.48	0.28	0.18	0.11	0.13	0.79	0.33	0.76	0.25	0.06	0.00	0.33	0.02	0.18	0.63	3.48

Acc. No.-Accession Number, Fec.-Fecundity, Hat %-Hatching Percentage, Wt_10-Weight of 10 larvae, Tld-Total larval duration, Vld- Fifth age larval duration, ERR no.- Effective Rate of Rearing by number, ERR wt.- Effective Rate of Rearing by weight, Pupa %-Pupation percentage, Cocoon-Cocoon weight, Shell-Shell weight, SR%-Shell Ratio, CY/100dfls-cocoon Yield/100dfls, FIL-LEN-Filament Length, NBF-Non Broken Filament Length

Discussion

Silkworm breeders while selecting parental breeds for their breeding programmes from the working germplasm or from gene banks want breeds with wide genetic divergence and proven and thoroughly characterized and evaluated materials. The statistical techniques they employ for selecting the breeds from the large collections are Subordinate function method (Gower, 1971 a, b) [5, 6], Joint scoring or ranking method (Arunachalam and Bandyopadhyay, 1984) [2] or Mano's Evaluation Index method (Mano *et al*., 1992 and 1993) [11, 12].

The above techniques were adopted by silkworm breeders in selecting and short listing multivoltine and bivoltine breeds for their breeding programmes (Nirmal Kumar, 1995; Nirmal Kumar and Sreerama Reddy, 1998; Sudhakar Rao *et al*., 2001; Lakshmi and Chandra Sekharaiah, 2008, Balachandran and Kamble, 2012, 2016) [15, 16, 17, 10, 3, 4].

Evaluation of genetic resources is the most important aspect of germplasm management, which decides the use of genotypes in various programmes of race improvement. The stock and race difference in biological characters are considered to be the result of adaptation during long generation (Murakami, 1994) [14].

Selection of suitable breeding resource material helps the breeder to successfully amalgamate desired traits. Appropriate experimental designs and selection methods employed in fixing the major traits contributing to the improved cocoon yield leads to the success of breeding programme. Understanding the genetic diversity of parental lines to be utilized in the breeding programme by systematic evaluation, critical assessment of their quantitative nature which is greatly influenced by the environmental factors such as temperature, light, relative humidity, nutrition and rearing techniques paves the way for the breeder for their effective utilization (Naseema Begum *et al*., 2001 and Sudhakara Rao *et al*., 2001) [14, 17].

Therefore the identified multivoltine silkworm accessions BMI-0074, BMI-0066, BMI-0065, BMI-0043, BMI-0027, BMI-0025 and BMI-0048 are some of the potential breeding resource materials which have performed well during all the seasons and hence they can be used as potential parental breeds for use in future breeding programmes.

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